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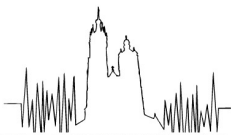
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Factors affecting transients in the speech of reed and flue pipes on mechanical action organs

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Summary

This paper describes an initial investigation into the speaking characteristics of reed organ pipes. There are a wide variety of pipes and individual pipe makers and voicers adopt their own processes. Measurements were taken of threshold and full speech for a range of resonator lengths. Much has been written about transient control on pipe organs and the paper considers how the characteristics identified might lead to varying transients.

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1. Introduction

In comparison with the extensive research literature on flue organ pipes, surprisingly little research has been carried out on reed organ pipes [1][2][3][4]. Pipe voicing is carried out by experienced voicers working essentially by ear. Voicing can be defined as obtaining the sound from a pipe that the organ builder wants to achieve and involves the physical manipulation of the various parts of the pipe to adjust the airflow through it. In the case of a reed pipe this includes the coupling of the vibrating reed to the resonator. This paper describes some preliminary work carried out on two reed organ pipes, one a clarinet supplied voiced by an organ builder with a curved reed, and a second one assembled by the researchers using an uncurved reed. The parts of a reed pipe are shown in Figure 1 [5].

In a conventional reed pipe, the brass reed or tongue is curved and held in place by a wooden wedge against the brass shallot, Figure 2. The length of the reed is adjusted by tapping the tuning spring (phosphor bronze) up or down. The length of the resonator is adjusted as part of the voicing and tuning process. Wilson and Beavers carried out research on a model clarinet with a metal reed

and showed that the threshold frequency (the frequency at the lowest possible blowing pressure)

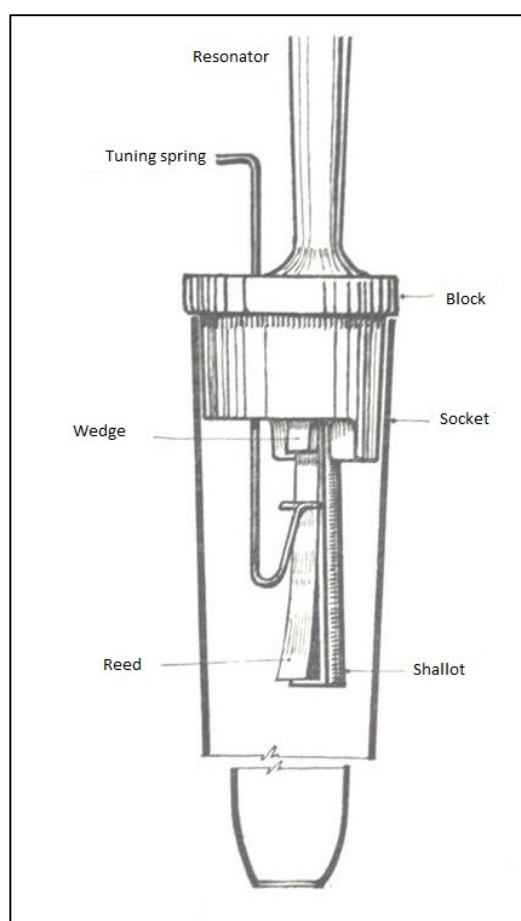


Figure 1. The speaking parts of a reed organ pipe

was strongly influenced by the length of the resonator [6]. They attributed this to the damping of the clarinet reed.



Figure 2. Side view of the shallot of the clarinet pipe showing the curved reed with the tuning spring pressing against it.

2. Experimental Results

Measurements were taken using two reed pipes.

2.1 Clarinet pipe

The first pipe examined was a clarinet pipe supplied voiced on a pressure of about 10mb by an organ builder [7]. This has an initial conical section to the resonator leading to a cylindrical section. The pipe was extended using cylindrical aluminium tubes. The resonant frequency of the tube was determined by playing white noise close to the end of the pipe and inserting a small microphone into the end of the tube, having established that the presence of the microphone made no significant difference to the measured resonance frequencies. The reed was bound closed with ptfе tape.

The reed frequency was determined by mechanically displacing the reed and releasing it and measuring the vibrations using a Baumer OADM-12U6430/S35A laser distance sensor and an IOtech Wavebook 516E data acquisition system, Figure 3. This was measured as $260 \pm 4\text{Hz}$. The pipe was then placed on a model windchest with a solenoid valve close to the pipe foot. The pressure was measured between the valve and the pipe foot.



Figure 3. Method for measuring the reed frequency using a laser distance sensor.

A microphone was placed close to the end of the pipe. The experimental arrangement is illustrated in Figure 4.



Figure 4. Clarinet pipe with cylindrical extension placed on windchest with pressure sensor between the toe and the top board.

Measurements were made of frequency for the threshold of speech against length of resonator. The minimum value for the length was 310mm as this was the length of the fixed resonator as supplied by the organ builder. The measurements were obtained by getting the pipe to speak fully and then reducing the pressure using a gate valve at the point of entry to the windchest of the tube from the pressure regulator until the point just before the pipe stopped sounding. The pressure was measured using a Sensortech HCTXM020D6H sensor. The frequency of full speech was also recorded. The pressures for threshold speech and full speech against resonator length are shown in Figure 5. Where no points are plotted on the graphs, it was not possible to get the pipe to speak on the pressure available from the wind system.

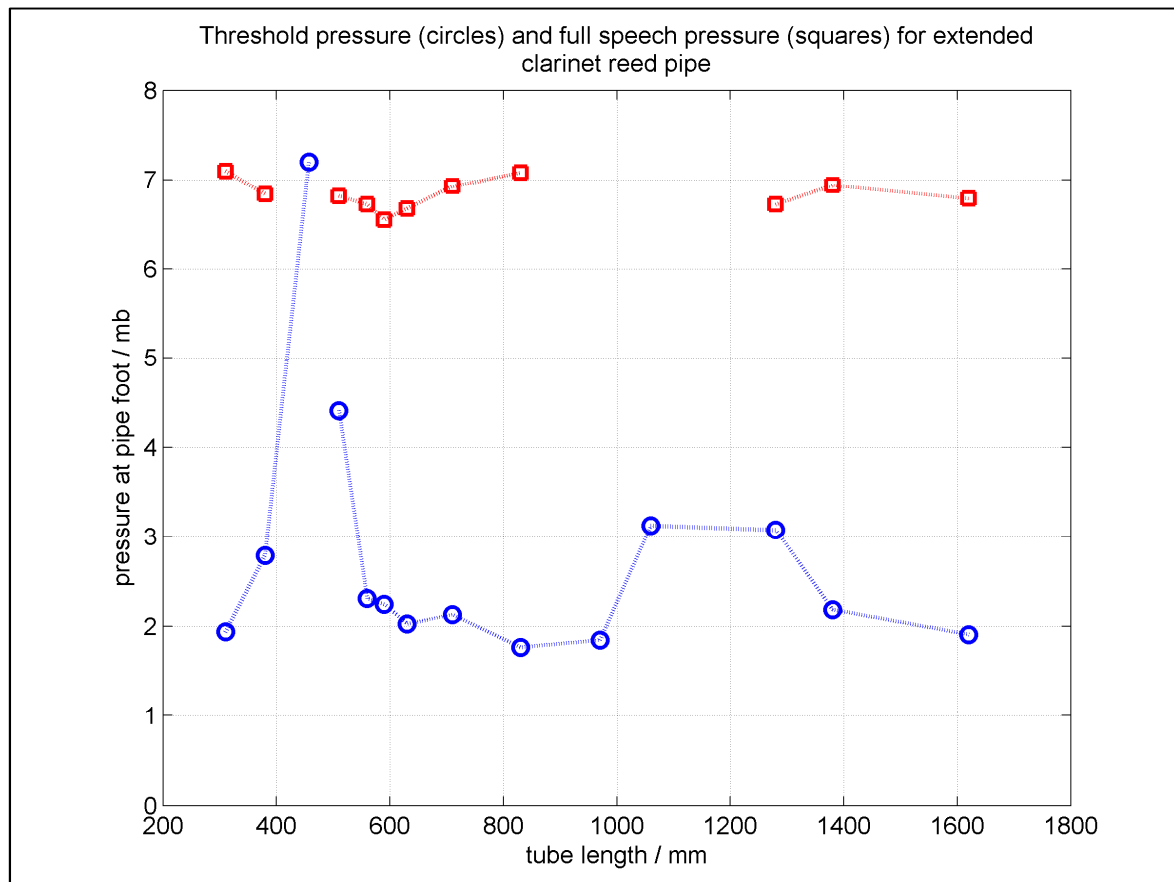


Figure 5. Graph showing the pressure immediately under the pipe foot against resonator length for threshold speech and full speech. Clarinet pipe.

Figure 6 shows the tube resonances (squares), of which four curves are clearly identifiable, and threshold frequencies (circles), full speech frequencies (diamonds) and reed frequencies (solid line) are plotted against tube length.

It can be clearly seen that the threshold speech frequency is very close to the reed frequency except when the tube resonance drops just below the reed frequency when the threshold frequency follows it

down for a short period and then jumps back up. At the first incidence, between about 450 and 500mm this led to instability of speech as noted above. Full speech, where it was achieved, also remained at around 339 Hz except where the tube resonance dropped just below it. This pipe consistently spoke initially at the reed frequency before jumping to the full speech frequency giving a very distinct transient. There was a range of lengths between 820 and 1250mm length in which it was not possible to get the pipe to speak on the pressure available.

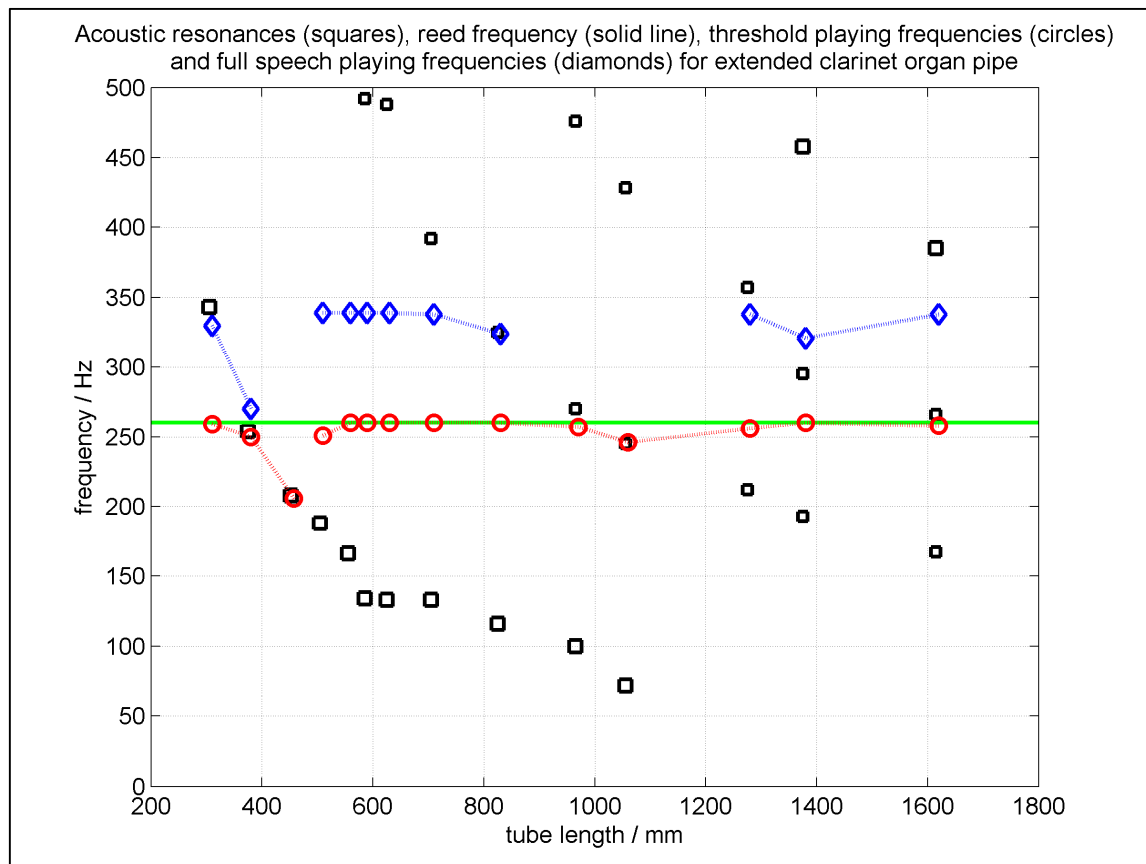


Figure 6. Graph showing the frequencies of the tube resonance, threshold speech and full speech along with the reed frequency. Clarinet pipe.

2.2 Pipe with flat reed

In order to make a comparison with the behaviour of the model clarinet reed studied by Wilson and Beavers, measurements were made using a second pipe. This was constructed from a spare block with a very short attached resonator with a flat piece of thin brass cut for the reed. As the reed in this configuration lay completely flat against the opening in the shallot, it would not speak and so a hair was inserted between the reed and the shallot (Figure 7). Similar measurements were taken for this pipe except that the tube resonance was determined by blowing across the end of the tube with the microphone placed a short distance inside it. The reed frequency was measured at 395 ± 6 Hz.



Figure 7. Photograph of the shallot of the flat reed pipe showing the hair necessary to create a gap between the reed and the shallot in order for the pipe to speak.

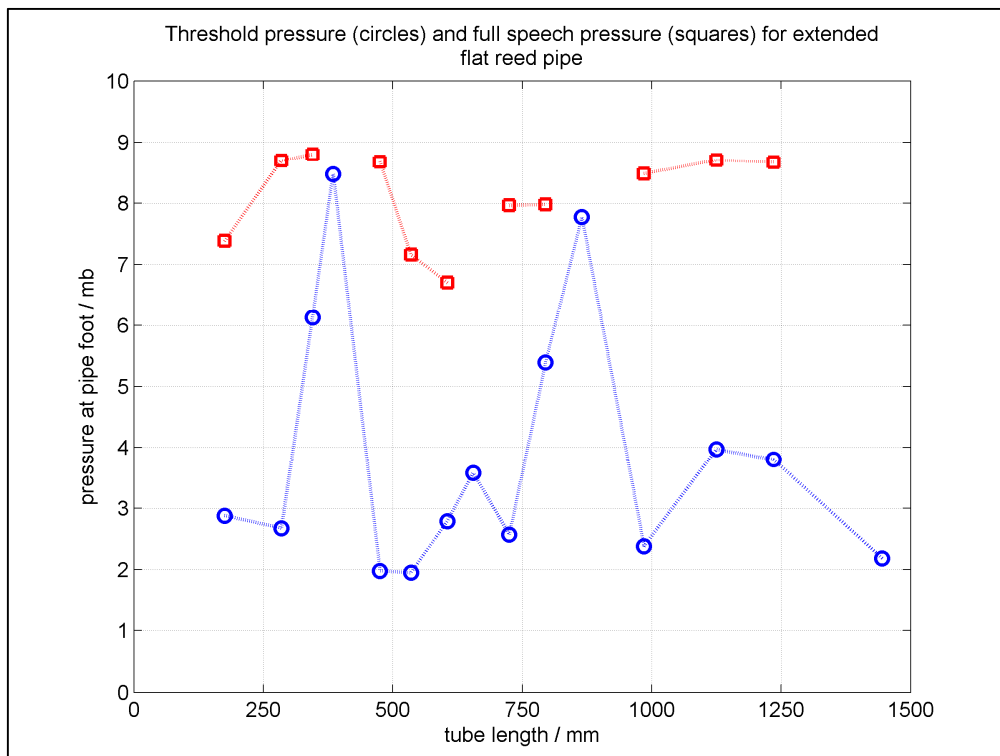


Figure 8. Graph showing the pressure immediately under the pipe foot against resonator length for threshold speech and full speech. Flat reed pipe.

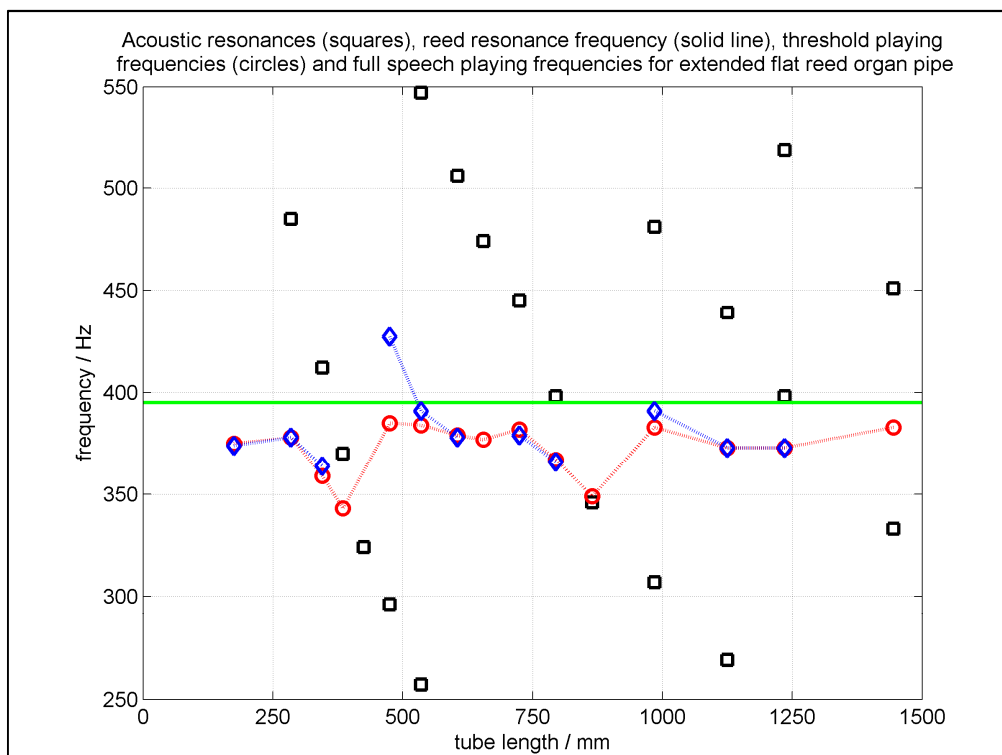


Figure 9. Graph showing the frequencies of the tube resonance, threshold speech and full speech along with the reed frequency. Flat reed pipe.

The results are similar to the clarinet pipe except that threshold speech was established at all lengths. Full speech was not achieved where no points are recorded.

This graph shows stronger coupling of the tube frequency and full speech frequency and, except after the first crossover point at around 450mm, the threshold frequency and full speech frequency are very similar and with the same exception, are always below the reed frequency.

3. Transients

Measurements of the transients were taken and an example is shown in Figure 10. Pressure measurements (upper, blue curve) and a sound recording (lower, red curve) for a transient of the clarinet pipe at its voiced length are shown. The pressure starts at atmospheric. This also shows that there is a delay from the pressure starting to rise at the point at which the key is depressed to the pipe starting to speak at the reed frequency. After about ten cycles it then jumps to full speech.

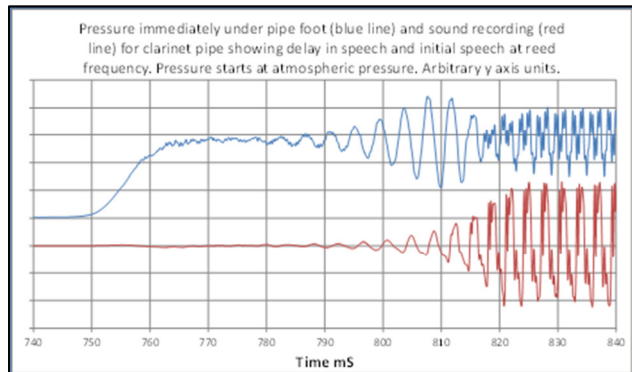


Figure 10. Transient of clarinet reed pipe showing pressure immediately under the foot (upper blue curve) and sound recording (lower, red curve).

4. Conclusions

Both pipes show some coupling of the threshold frequency and the tube resonance. Wilson and Beavers only considered the threshold frequency in their measurements of the clarinet model and this showed significantly greater coupling with the tube resonance. They attributed this to damping of the reed although this has not been studied in this investigation. An earlier paper noted that when a pipe takes a significant time to reach full speech, the proportion of the initial speech to the full

speech will vary with the total length of the note which may give the impression of a varying transient [8].

The difference in pressure required for threshold and full speech of both pipes and the difference in frequency between the two for the clarinet pipe means that any variation of pressure over time when the valve under the pipe is opened may lead to a distinct transient. This was particularly the case with the clarinet pipe which initially spoke at the reed frequency before jumping to the full speech frequency. Pressure variations in the windchest due to the playing of previous notes may also be of sufficient magnitude to modify the transients.

The reed frequency is the critical factor in the tuning and voicing of reed organ pipes and this should be the predominant factor in voicing reed organ pipes before the length of the resonator is determined. This will form a major part of the continuation of this investigation.

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